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Reinforcement and Outburst Prevention Technology of Reserved Coal in Advance Excavation of Soft High-outburst Coal Seam

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Abstract

Drilling-induced and outburst prevention technology and equipment of soft coal seam high-outburst areas is a new technology. Coal within advance distance is taken as the research object, and mechanical principles are used to analyze it. From the mechanical balance point, temporary reinforcement program is proposed, which is a fundamental solution to induced outburst issue in the drilling process with high Innovation. Especially the one-time anchoring agent fixator is smartly designed to solve the contradiction between anchoring and tunnelling. The technology theory is mature, and it will play a significant role in excavation and outburst prevention of soft coal seam high-outburst areas after improving the construction process.

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Keywords:soft high-outburst coal seam; reserved coal; reinforcement technology

The premise of coal and gas outburst is that the gas in porous media must produce a strong movement. To make the gas in motion, gas pressure gradient and concentration gradient must form in the porous medium; the gradient is the driving force of gas movement, rather than the absolute pressure value and concentration magnitude of gas in coal. Therefore, the absolute pressure value of gas and coal and gas outburst is not directly related, only the pressure gradient and change range of gradient are root causes of coal and gas outburst. (A)After the implementation of advancing hole， part of the gas is released , but there is still a large pressure gradient, especially after the implementation of advance hole, the original physical structure of coal is destroyed within advance distance, and the shear strength decreases rapidly.(B)When hole enters into the soft coal layer, rotary cut of the drill bit produces a shock and crushing force of soft coal, which makes the coal burst and crush, and the

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broken and crushed coal produces gas desorption rapidly. The coal around the hole has rapid gas desorption, so that the gas into the hole is several times to several tens of times of the normal emission gas. At this time a larger gas gradient appears in the front and the back of the hole, thus the intensity of gas emission increases significantly. High-speed gas flow plays a delivery and pulverization role of the damaged coal particles, and also continues to expand its influence range around the hole. Due to the small aperture of the hole, high-speed gas flow and pulverization coal particles are difficult to smoothly discharge to the outside of hole, which further increases the gas pressure gradient inside and outside the hole. At last the gas emission changes into explosive gas outflow from the inside to outside, jet orifice and sticking are formed, hole depth is low, when the intensity F is greater than the total shear resistance T of coal skeleton, coal and gas outburst occurs.

1. Reinforcement Technology Program

- The advance emission hole is used, the anchoring agent is loaded, the temporary reinforcement tubes are used, and the coal within the advance distance is solidificated as a whole, each temporary reinforcement tube pre-stress is 2t;
- Cold wire drawing steel mesh is added to temporary reinforcement tube ends, steel mesh and temporary reinforced tube are connected as a single entity for the reinforcement of coal.
- On four corners of roadway, along the direction of 30 °,hole is drilled 5m to the roof and floor rock, in which, 2m enters the roof and floor rock , the temporary anchoring agent and the reinforcement tubes are loaded, each tube temporary reinforcement pre-stress is 5t.

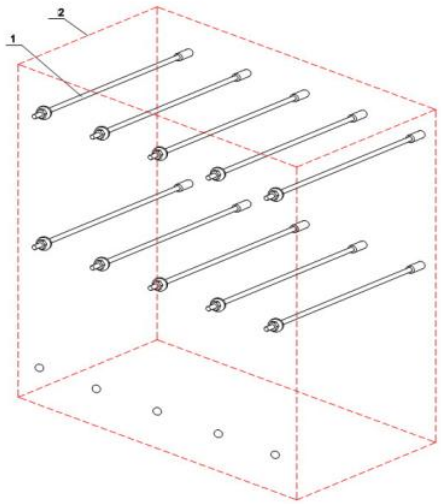


Fig. 1. diagram1 of coal solidification within the advance distance

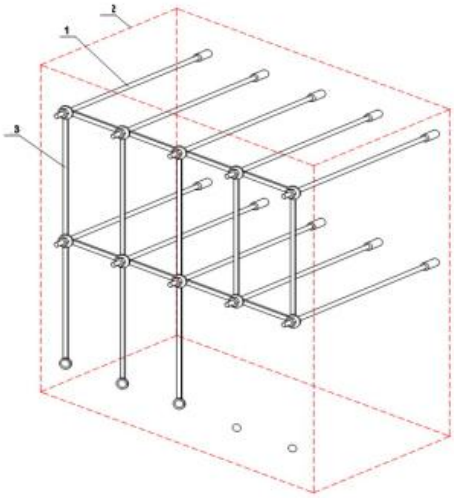


Fig. 2. diagram 2 of coal solidification within the advance distance

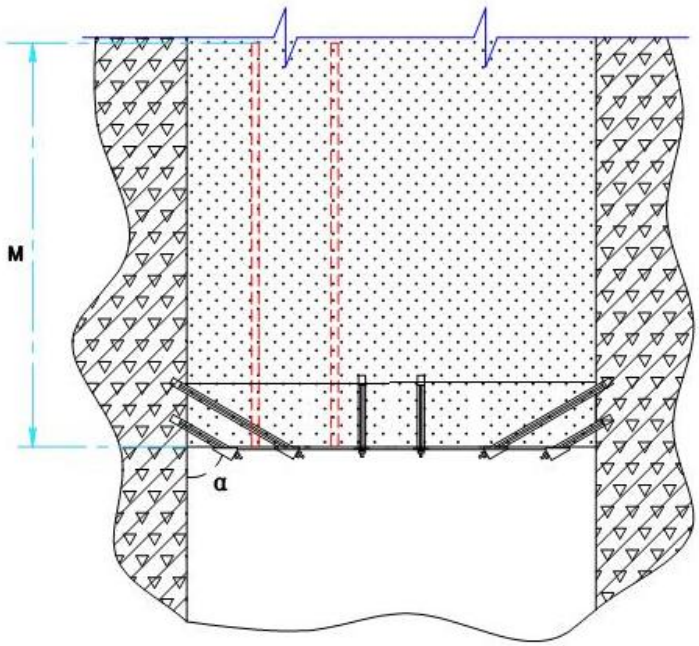


Fig. 3. diagram 3 of coal solidification within the advance distance

2. Effect Analysis by Application of Numerical Simulation FLAC3D

2.1. Project Overview and Model

Seam thickness is stable, and structure is simple, semi-bright type of coking coal. Coal thickness is generally 3-4m with an average of 3.5m.Seam angle changes little, and it can be approximated as horizontal coal seam, the fluctuant change of coal seam is little , depth is about 600m. The situation of coal seam roof and floor: The immediate roof, bottom are both sandy mudstone, the top of immediate roof is a thin layer of mudstone, and main roof is neutral sandstone. The floor is banded sandstone, the top is dark mudstone and the middle is sandy mudstone. Mechanical properties of coal seam and rock and physical and mechanical parameters around the roadway are specific shown in Table 1. According to geological conditions and the actual surface situation, a three-dimensional mathematical model is established, as is shown in Figure 5.

Table 1 Physical parameters of coal rock

Lithology description	DensityKg/m^3	K Bulk modulus	G Shear modulus	C(Mpa) Bond strength	Ψ Internal friction angle	ten(Mpa) Compressive strength	Remarks
medium coarse sand	2400	$9.81e^9$	$2e^9$	5.1	32	30.3	
Mudstone	2530	$8.3e^9$	$3.5e^9$	0.5	40	25	
Sandy mudstone	2600	$4e^9$	$3.5e^9$	5.75	30	28.5	
Hard coal	1750	$3.81e^8$	$3.48e^8$	0.2	31	17.5.	
Soft coal	1750	$3.81e^8$	$3.48e^8$	0.2	31	9.5	
Sandy mudstone	2300	$8.8e^9$	$3.5e^9$	8.1	16	28.5	

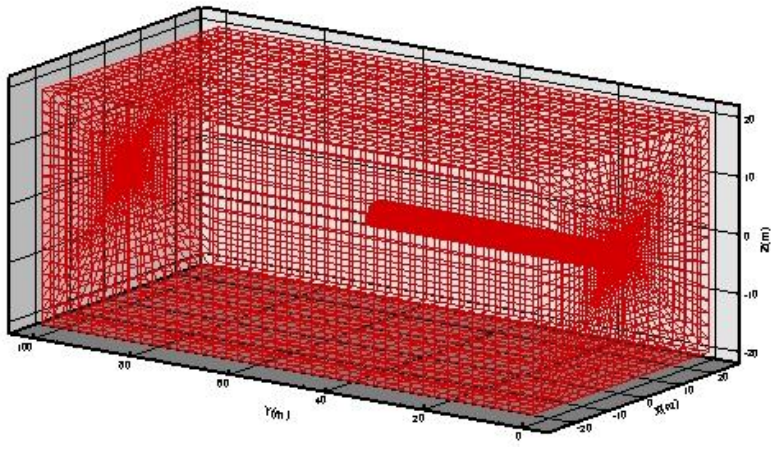
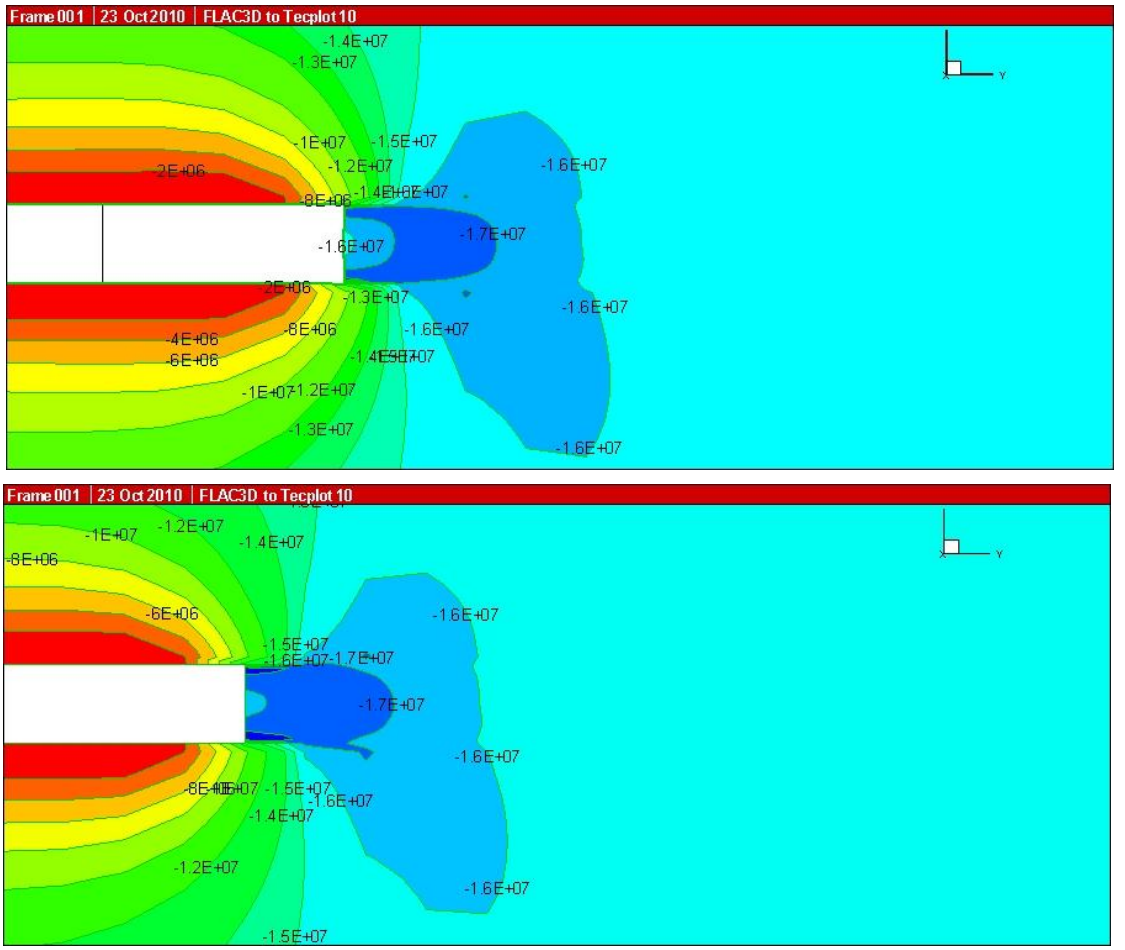


Fig. 4. FLAC3D model

It is divided by the even unit mesh obtained by the study scope, that is, small units are used close to the working face, units are growing away from the working face. The discrete division size of rock unit, can guarantee the necessary accuracy of calculation.

2.2. Simulation and Effect analysis



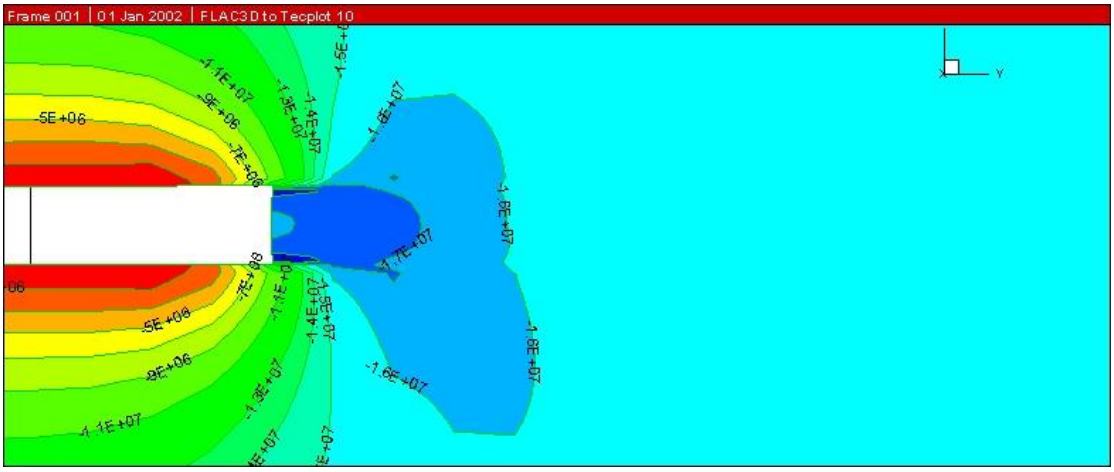


Fig. 5. (a) Not advance reinforcement; (b) before Added after the reinforcement (50KN); (c) before Added after the reinforcement (100KN)

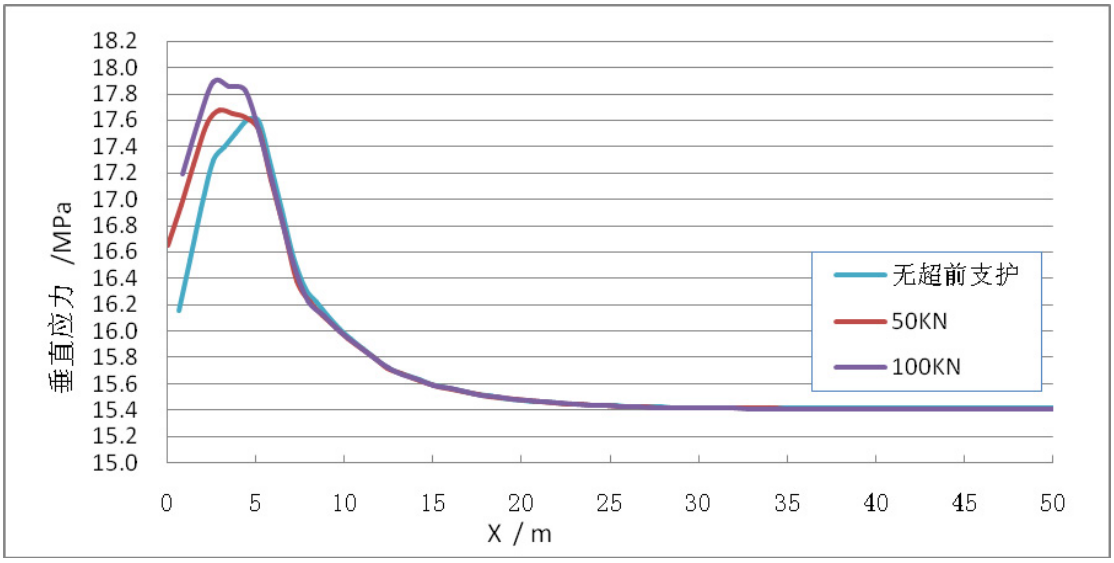


Fig. 6. vertical stress curves

Figure 5, Figure 6 show that, with increasing support resistance, the vertical stress increases in front of excavation, the trend is the same with the hard coal seam, and the increasing range is 0-5m, the areas after 5m are not affected by the advanced pre-stressed support. Under the action of the anchor bolt, original broken coal comes into a whole coal, and the ability of overall resistance against coal gas outburst is enhanced.

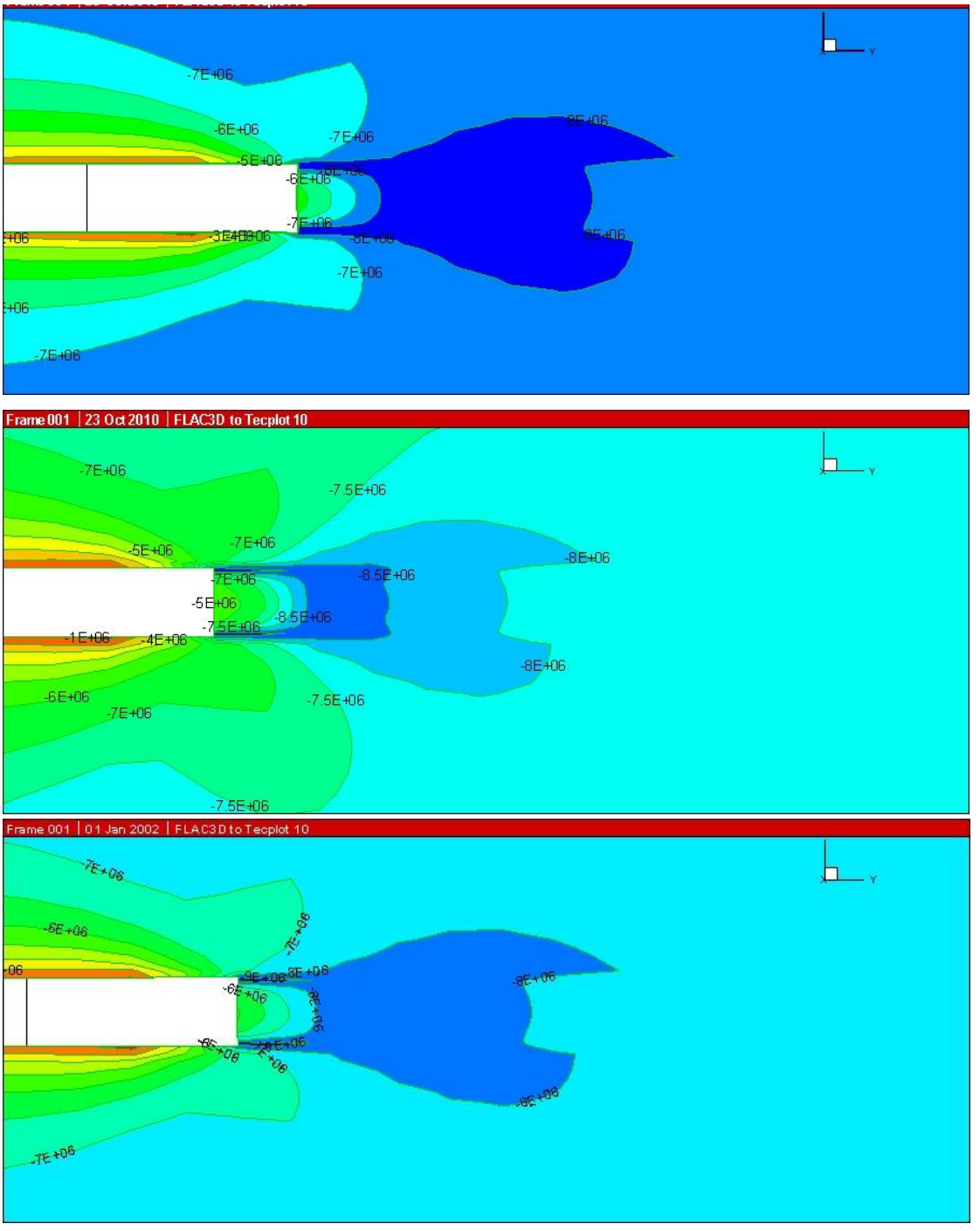


Fig. 7. (a) Not advance reinforcement; (b) before Added after the reinforcement (50KN); (c) before Added after the reinforcement (100KN)

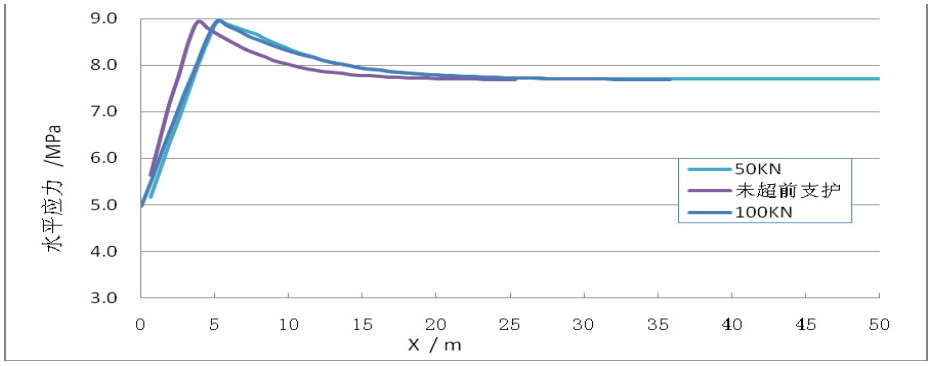


Fig. 8. vertical stress curves

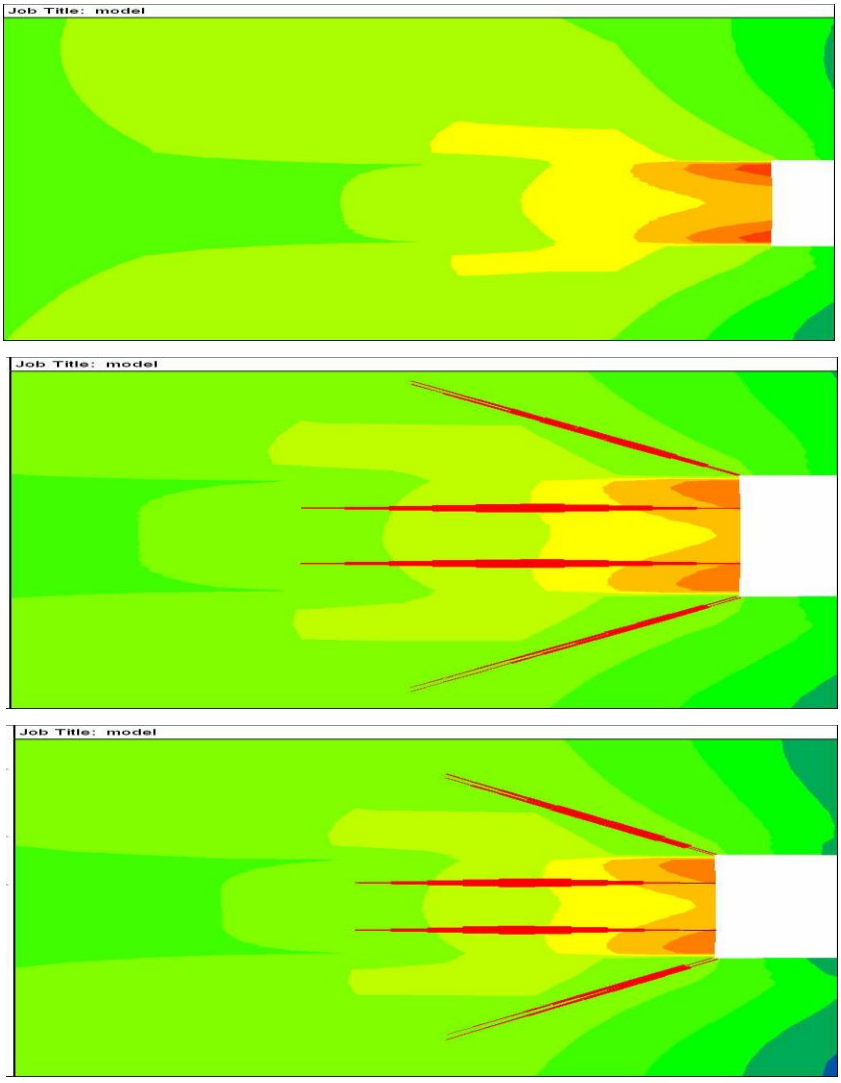


Fig.9. (a) Not advance reinforcement; (b) before Added after the reinforcement (50KN); (c) before Added after the reinforcement (100KN)

We can see: With the support resistance increases, shear stress concentration reduces. When there is no support resistance, and the range of shear stress concentration is large, above the 10-15m range of the end face, there is shear stress concentration. With the support resistance increases, shear stress concentration area in front of the coal wall becomes smaller and smaller as the 0-5, shear stress concentration disappears on upper and lower corners of tunneling place.

3. Conclusions

Through analysis and comparison of the results, follows can be concluded:

- The front of the roadway is advance supported and reinforced by prestressed anchors made with special material, and the range of reinforcement is advance reserved coal. Coal has compressive deformation in the role of special anchor bolt, which makes the original broken coal into a whole, and capacity of coal resistance to compression and shear increases in anchorage areas, the ability to resist gas outburst is enhanced.
- Advance pre-stressed anchor can make the horizontal stress peak slightly move back, but the impact is limited.
- With the support resistance increases, the concentration of shear stress reduces, shear stress concentration area became smaller, shear stress concentration disappears on upper and lower corners .As mine gas outbursts are most the shear failure for the coal, and the decrease of shear stress concentration can reduce the risk of mine gas outburst.

Through analysis and comparison of the results, we can draw:

- The front of the roadway is advance supported and reinforced by pre-stressed anchors made with special material, and the range of reinforcement is advance reserved coal. Coal has compressive deformation in the role of special anchor bolt, which makes the original broken coal into a whole, and capacity of coal resistance to compression and shear increases in anchorage areas, the ability to resist gas outburst is enhanced.

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